Forecasting Feed and Residual Use of Wheat

by
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Abstract: In recent years, feed and residual use of wheat has been large both during the summer quarter and for the entire year. Equations were developed to estimate both quarterly and the annual feed and residual use of wheat. Previous research (Allen and Westcott, 1991) estimated linear equations using price and non-price factors. Many alternative functional forms were examined using price and non-price factors for this analysis. USDA price forecasts presented at the Agriculture Outlook Forum in February 1997 (P. Riley) along with the estimated equations, imply a 1997/98 feed and residual use of 397 million bushels in the summer quarter and between 286 and 331 million bushels for the year.

Keywords: Wheat feeding, forecasting, prices

In the Southern Plains and the Southwest, where wheat and livestock are produced together, wheat is commonly used as a feed source. Most of the wheat fed is lower quality wheat which is used in feed rations. Factors supporting the feeding of wheat include: (1) wheat prices are lower during the summer quarter (June through August) relative to other feed grains due to the newly harvested winter wheat crop, (2) transporting feed grains in from other regions is costly, and (3) supplies of winter wheat are generally available in these areas. In 1990/91, low wheat prices relative to corn and sorghum led to a record wheat feeding of 399.7 million bushels for the summer quarter. More recently, in the summer quarter of 1996, wheat feed and residual disappearance reached 381 million bushels, the second highest on record.

Feed and Residual Use of Wheat

The feed and residual use category for wheat includes all nonfood and nonseed domestic uses, including statistical residuals (errors) from all categories of wheat supply and demand. From the supply and demand balance sheet, wheat feed and residual use is simply a residual calculation. Supply (beginning stocks, production, and imports) minus ending stocks gives total disappearance. Subtracting exports and use leaves an unexplained disappearance labeled feed and residual use. Patterns of feed and residual use tend to be large and positive in the first quarter, negative in the second, and positive or negative in the third and fourth quarters. All the estimates of uses mentioned above, except feed and residual use, come from various government surveys. There are no reports, either government or private, that estimate the actual feeding of any grain, including wheat.

Wheat feeding in the summer quarter occurs primarily because winter wheat is harvested in June and July. At this time, wheat is generally priced lower than other feed grains. Most feed grains are not harvested until fall, so during the summer, their prices have not declined to harvesttime lows. The seasonal combination of low wheat prices and higher corn and sorghum prices often makes it attractive to use wheat in concentrate feed rations in wheat growing areas. Also, poor quality wheat is more likely to be discounted for feed use rather than put into storage.

Second-quarter (September through November) feed and residual use of wheat is often negative. Within the supply and demand balance sheet, this would be caused by the sum of domestic use, exports, and ending stocks exceeding the supply (second quarter beginning stocks plus imports) of wheat. Because the wheat harvest occurs in the first quarter and beginning stocks are fixed, excluding any revisions by the National Agricultural Statistics Service (NASS), only imports could increase enough to offset the gains found in demand. Often this does not occur and therefore the feed and residual use of wheat is negative in the second quarter. The same result could occur in the third (December through February) as well as the fourth quarter (March through April).

The interpretation of feed and residual use is often difficult because the feed and residual use of wheat is determined by other factors in the supply and demand balance sheet.

Economic Model

Feed demand hinges upon derived demand theory. In other words, feed wheat is used as an input to produce a desired output product. In this case, the output product is livestock. Under these circumstances, input demand depends upon the prices of the input, substitute inputs, and the output. Since there isn't any data for actual feeding of wheat, the historical feed and residual estimates were used as a proxy.

Wheat price represents the input price and corn price represents a substitute feed grain price. Sorghum and other feed grain prices tend to follow corn prices. For this analysis, season average farm prices were used. The value of the output can be measured as the price of fed beef. In this case, an index of prices received by farmers for livestock and products (as published by NASS in Agricultural Prices) was used.

Using only prices could potentially underestimate the amount of wheat feeding. Aggregate prices often do not fully capture regional quality differences among the classes of wheat. Consequently, non-price factors were examined also. These included the number of animals on feed as well as the size of

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the wheat supply. Two variables were developed to represent the number of animals on feed. The Southern Plains represent a major wheat growing area of hard red winter wheat and because it has large cattle-feeding operations, a cattle on feed (CAOF) variable on July 1 was examined. Because some wheat is fed to poultry, especially soft red winter, a variable was developed to capture this effect. Broiler production numbers in Arkansas (ARKB) were chosen because that State is a large broiler and wheat producer, and is located close to larger wheat producers. Wheat supply was measured by two variables: beginning stocks plus winter wheat production (Sw), and beginning stocks plus total wheat production (St). A time trend variable was also used to capture the growth in the scale of the sector.

The non-price variables, CAOF and ARKB, are expected to have a positive effect on the feeding of wheat. As the number of cattle on feed and broilers increase, more feed wheat is expected to be used. In theory, the supply of the wheat crop is also expected to have a positive effect upon the feeding of wheat. As the wheat supply increases, generally price is expected to decline, therefore making it economically attractive to feed wheat rather than corn or some other feed grain. In practice, some analysts feel that the supply of wheat may be correlated with the residual component rather than actual wheat feeding.

In an attempt to capture the interaction between the price variables, corn and wheat, several different variables were examined. These included: SPRD, WhCn, and WCinv. The SPRD variable equals the spread between wheat price and corn price. This variable is expected to have a negative effect on wheat feeding. As the price of wheat increases so does the spread, causing the amount of wheat feeding to decrease as corn becomes more attractive to feed. The WhCn variable equals wheat price divided by corn price. It is expected to have a negative effect as well because as the wheat price increases so does the ratio, causing wheat feeding to decline. The WCinv variable equals one divided by the WhCn variable. This variable is, however, expected to have a positive effect on wheat feeding. As the price of wheat increases, the WCinv value would decrease. This would cause wheat feeding to decrease as it becomes cheaper to feed corn than wheat.

Model Estimation Results

Considering linear, log-linear, log-log and inverse functional forms, Ordinary Least Squares (OLS) was used to estimate quarterly and annual equations. Data from 1977 to 1996 were used to estimate equations for quarters one and two. To estimate equations for quarters three and four and also the annual, data from 1977 to 1995 were used. The quarterly and annual equations are shown in table D-1. Each annual and quarterly model was evaluated given the selected functional forms. The models shown in table 1 perform the best, based on correct signs of the independent variables, significance, and overall explanatory power. The models shown in table D-1 also used only price variables and a time trend variable in some combination. Although some non-price factor variables were developed and examined, overall model performance was better without them.

The summer quarter (quarter 1) model yielded the highest R square value of 0.96. The explanatory power of the other quarters are not as high, with the quarter four model yielding the lowest explanatory power of 0.65. The signs of the independent variables in each quarterly equation are as expected and statistically significant. The annual model performed quite well yielding a R square of 0.85. The signs of the independent variables are as expected and their associated t-statistics are quite significant due to their low standard errors.

As shown in table D-2, the models' predicted power was quite strong . In the early 1990's, the models seem to perform better, even when feeding was very large. For example, in 1990/91 when summer quarter feeding reached a record 399.7 million bushels, the model predicted 395.4, only a -4.3 million bushel error for the model. In 1991 and 1992, the summer quarter models performed quite well where the errors were only +11.3 and -12.5 million bushels, respectively. Generally speaking, the other models did well in these 3 years also, but from 1993 to 1995 model error increased.

The development of the quarterly and annual models could be used together to estimate a range for the annual feed and residual use of wheat. An annual estimate could be derived either by summing each quarter or by evaluating the annual model. Although the quarterly models could be used to derive an annual estimate, the original motive for their development is primarily for short term forecasting. For longer term forecasting, the annual model was developed. Although all these models with their respective functional forms perform quite well when evaluating predicted versus actual values, their worth as forecasting tools has yet to be evaluated.

Model Forecasting

A more difficult test upon all these models and their respective functional forms consists of going back in time and using the same variables and functional forms to forecast a future year. Actually, this is more of a functional form test than a model test because in specified years each model may have performed better using a different combination of independent variables. Nonetheless, this type of test reveals over time how well each functional form forecasts.

For example, to forecast 1990, regression equations would be based upon data up to 1989. Then using expected prices, a forecast for 1990 could be derived. To forecast 1991, regression equations would consider data up to 1990, and again using expected prices, a forecast for 1991 could be reached. Data in table D-3 show these results from 1990 to 1997 for the summer quarter and annual models.

Once again, in the early 1990s the forecast power of the summer quarter model performed well, only missing the record feeding year in 1990 by +14.3 million bushels. In 1991, the error was less than +4 million bushels. However, closer to 1995 the error did increase. The annual model performed quite well also. In table D-3, there are two annual forecasts. One is derived by the annual model and the other represents the sum of each quarter. Aside from 1994, these two forecasts perform better in the latter part of the 1990s.

In 1993 and 1995, the errors were only +2.6 and +7.9 million bushels for the quarterly sum and annual forecast, respectively.

Forecast 1997/98 Feed and Residual Use of Wheat

For this analysis, wheat and corn prices are assumed to be $3.45 and $2.50, respectively. Using these expected prices, the equations imply a feed and residual use ranging between 286 and 331 million bushels for crop year 1997/98. Also, these equations imply a feed and residual use of 397 million bushels for the 1997 summer quarter and if realized it would be the second highest on record.

Table D-1--Regression results for quarterly and annual feed and residual use of wheat

Time period	Functional form	Mean of dependent variable 1/	Variable	Estimated coefficient	T-statistic	Mean elasticity	R square
Quarter 1							
Jun.-Aug.	Log-log	209.39	Constant	5.14	21.92	0.963	0.96
			lnWhP 2/	-1.26	-3.29	-0.276	
			lnCnP 3/	0.38	1.12	0.065	
			lnTime 4/	0.67	10.41	0.266	
			D79**	-0.93	-4.47	-0.009	
			D80**	-0.90	-4.61	-0.008	
Quarter 2							
Sept.-Nov.	Linear	-14.09	Constant	146.73	2.62	-10.416	0.80
			WhCn 5/	-92.12	-2.08	8.707	
			Time	-4.46	-3.38	3.320	
			D83**	86.08	2.64	-0.306	
			D84**	86.20	2.58	-0.306	
Quarter 3							
Dec.-Feb.	Inverse	21.51	Constant	-17.61	-0.52	-0.819	0.69
			WCinv 6/	49.69	1.13	1.795	
			D90 **	73.53	3.69	0.180	
			D88**	-63.77	-3.38	-0.156	
Quarter 4							
Mar.-Apr.	Inverse	-13.91	Constant	-52.72	-1.02	3.791	0.65
			WCinv	100.00	1.67	-5.585	
			Time	-3.57	-3.14	2.567	
			D91**	-60.02	-2.27	0.227	
Annual	Log-linear	210.40	Constant	5.91	17.00	1.104	0.85
Jun.-May			WhP	-1.06	-6.67	-0.645	
			CnP	0.94	4.84	0.437	
			Time	0.06	4.97	0.109	
			D80**	-0.55	-1.97	-0.005	

1/ Reported as the antilog of the mean for logarithm models. 2/ Natural logarithm of the season average farm price (SAP) for all wheat. 3/ Natural logarithm of the SAP for corn. 4/ Natural logarithm of time, where 1977=ln1....1995=ln19. 5/ WhCn variable: SAP for all wheat/SAP for corn.
6/ Inverse variable: 1/WhCn. 5/ WhCn variable: SAP for all wheat / SAP for corn.
**Indicates a dummy variable for the respective year: D79 indicates a dummy for 1979.

Table D-2--Quarterly and annual actual versus predicted feed and residual values, 1977-1995

Year	Q1 - June to August Actual	Q1 Predicted	Q1 Residual	Q2 - September to November Actual	Q2 Predicted	Q2 Residual
1977	117.1	87.6	-29	37.0	40.8	4
1978	80.8	99.2	18	33.0	16.6	-16
1979	38.1	38.2	0	-8.5	-2.7	6
1980	48.1	48.2	0	4.9	-0.6	-5
1981	144.9	152.6	8	-7.1	14.6	22
1982	131.3	178.0	47	18.8	-4.7	-23
1983	196.1	205.9	10	100.5	100.5	0
1984	279.6	235.2	-44	101.5	101.5	0
1985	235.5	274.1	39	65.9	-0.2	-66
1986	352.3	364.6	12	-20.8	-4.1	17
1987	363.8	347.1	-17	-79.1	-39.6	40
1988	282.2	272.7	-10	-49.4	-30.9	19
1989	264.9	252.8	-12	-87.8	-55.5	32
1990	399.7	395.4	-4	-38.3	-15.9	22
1991	359.1	370.4	11	-26.9	-36.7	-10
1992	345.9	333.4	-13	-81.9	-68.7	13
1993	295.8	370.4	75	-38.5	-49.1	-11
1994	376.3	344.8	-31	-28.8	-74.1	-45
1995	305.0	288.5	-17	-98.8	-68.9	30

Year	Q3 - December to February Actual	Q3 Predicted	Q3 Residual	Q4 - March to May Actual	Q4 Predicted	Q4 Residual
1977	28.3	27.5	-1	10.1	34.5	24
1978	21.4	20.1	-1	22.3	16.1	-6
1979	31.1	16.0	-15	25.2	4.3	-21
1980	8.1	17.7	10	-2.1	4.1	6
1981	-7.6	24.0	32	4.6	13.3	9
1982	24.2	19.1	-5	20.5	-0.3	-21
1983	48.3	27.7	-21	26.2	13.4	-13
1984	35.5	30.2	-5	-9.5	14.9	24
1986	48.7	25.5	-23	20.9	-1.7	-23
1987	-7.3	15.7	23	12.8	-24.9	-38
1989	37.4	14.1	-23	-75.4	-35.3	40
1990	101.6	101.6	0	19.5	-10.9	-30
1992	4.8	14.1	9	-75.2	-46.0	29
1993	39.0	20.5	-19	-24.7	-36.7	-12
1994	25.5	14.9	-11	-28.6	-51.5	-23
1995	12.8	17.3	5	-66.9	-50.2	17

Year	Annual - June to May Actual	Predicted	Residual
1977	192.5	250.6	58
1978	157.5	152.4	-5
1979	85.9	86.3	0
1980	59.0	59.0	0
1981	134.8	177.9	43
1982	194.8	151.1	-44
1983	371.1	265.7	-105
1984	407.1	337.2	-70
1985	284.3	290.0	6
1986	401.1	366.2	-35
1987	290.2	248.6	-42
1988	150.5	204.3	54
1989	139.1	134.2	-5
1990	482.5	468.4	-14
1991	244.4	333.5	89
1992	193.6	206.7	13
1993	271.6	321.0	49
1994	344.5	222.0	-122
1995	152.1	176.1	24

Table D-3--Forecast summer quarter and annual feed and residual use of wheat

	Summer 1/			Annual 2/				
	Actual	Forecast 3/	Residual	Actual	Forecast 4/	Residual	Forecast 5/	Residual
1990	399.7	414.0	14.30	482.4	524.0	41.60	404.0	-78.40
1991	359.1	363.0	3.90	244.5	356.0	111.54	306.0	61.54
1992	345.9	303.0	-42.90	193.7	194.0	0.35	179.0	-14.65
1993	295.8	359.0	63.20	271.7	311.0	39.31	274.0	2.31
1994	376.0	314.0	-62.00	345.0	203.0	-142.00	181.0	-164.00
1995	305.0	257.0	-48.00	152.1	194.0	41.94	160.0	7.94
1996	381.0	282.0	-99.00	300.0*	152.0		135.0	
1997		397.0			331.0		286.0	

1/ June to August. 2/ Crop year; May to June. 3/ Estimated using quarter 1 equation. 4/ Estimated using annual equation.
5/ Sum of quarterly estimates.

*Annual estimate published in the World Agricultural Supply and Demand Estimates, USDA, February 1997.